(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 406 824 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 90112760.5

(51) Int. Cl.5: C30B 15/02

(22) Date of filing: 04.07.90

(30) Priority: 05.07.89 JP 173676/89

(43) Date of publication of application:
09.01.91 Bulletin 91/02

(84) Designated Contracting States:
DE FR GB IT NL

(71) Applicant: NKK CORPORATION
1-2, Marunouchi 1-chome Chiyoda-ku
Tokyo 100(JP)

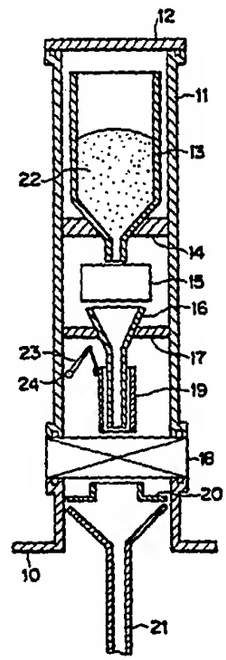
(72) Inventor: Mohri, Yoshio, c/o Patent &
Lincense Departmentent
NKK Keihin Bldg, 1-1, Minamiwatarida-cho
Kawasaki-ku, Kawasaki 210(JP)

(74) Representative: Füchsle, Klaus, Dipl.-Ing. et al
Hoffmann . Eitle & Partner Patentanwälte
Arabellastrasse 4e 4
D-8000 München 81(DE)

(54) Apparatus for feeding granular silicon material.

(57) The invention relates to an apparatus for feeding granular silicon material which comprises a hopper (13) for storing granular silicon material, a feeder (15) for feeding the granular silicon material stored in the hopper (13), a first guide tube (16) for leading granular silicon material fed from the feeder (15), a feed tube (19) for feeding granular silicon material, which is arranged in a lower portion of the first guide tube (16) and movable upward and downward, a housing (11) incorporating the hopper (13), the feeder (15) the first guide tube (16) and the feed tube (19), a sluice valve (18) for closing an opening of a chamber of the apparatus for manufacturing silicon single crystals, and a second guide tube (21) which is positioned in a portion of the opening of a chamber (10) and which leads granular silicon material to a crucible for melting granular silicon material.

FIG. 1



EP 0 406 824 A1

APPARATUS FOR FEEDING GRANULAR SILICON MATERIAL

The present invention relates to an apparatus for manufacturing a silicon single crystal by means of the "Czochralski pulling technique", and more particularly to a method for feeding granular silicon into a crucible.

Apparatus heretofore known for the manufacture of silicon single crystals by the Czochralski method includes apparatus of the type which continuously pulls a silicon single crystal while feeding granular silicon into a crucible. The silicon single crystal is grown in an inert atmosphere under reduced pressure to avoid incorporation of impurities into the molten silicon. Accordingly, an apparatus for feeding granular silicon material comprises a material storage hopper, a feeder, a guide tube and a housing enclosing said hopper, said feeder and said guide tube. The granular silicon material is stored in the material storage hopper. Every predetermined amount of said silicon material discharged from a lower discharge port of the hopper is fed by the feeder to the crucible through the guide tube. A Japanese Examined Patent Publication No.17537/86 discloses an example of the aforementioned.

In the "Czochralski pulling technique" wherein the granular silicon material is continuously fed into the crucible, when the granular silicon material in the hopper has been used up, the hopper is replenished with granular silicon material. When the granular silicon material is charged into the hopper, measures should be taken in order that air cannot be included into a chamber of an apparatus for pulling a silicon single crystal. Accordingly, a sluice valve, which can cut off a communication between the hopper and the chamber, and which is fit for vacuum sealing, is mounted on a position of the housing enclosing the material storage hopper. The granular silicon material is charged into the hopper after the sluice valve has been closed and the pressure inside the housing having the hopper therein has been elevated to atmospheric pressure.

However, when the sluice valve is mounted on one position of the housing, the guide tube leading the granular silicon to the crucible cannot be arranged, passing through the sluice valve. That is, the guide tube is divided into two portions before and behind the sluice valve. Accordingly, when the granular silicon is fed to the crucible, the granular silicon freely falls by its weight from the guide tube positioned before the sluice valve into the guide tube positioned behind the sluice valve. During the fall of the granular silicon, the granular silicon strikes the guide tube positioned behind the sluice valve, and either bounds or scatters. When the granular silicon bounds or scatters, particles of silicon attach to the surface of a seat of the sluice valve or accumulate thereon. In the case that the particles of silicon are attaching to the surface of the seat of the sluice valve, when fresh granular silicon is charged into the hopper, the particles of silicon bite into between the seat and the disc of the sluice valve although the sluice valve is closed, which lowers the ability of the sluice valve for vacuum sealing. In consequence, air is included into the chamber, and the successive growth of silicon single crystals cannot be carried out.

It is an object of the present invention to provide an apparatus for feeding granular silicon material, wherein silicon single crystals can be continuously manufactured for a long period of time.

To attain the aforementioned object, the present invention provides an apparatus for feeding granular silicon material comprising:

a hopper for storing granular silicon material;

a feeder for feeding granular silicon material stored in said hopper;

a first guide tube for leading granular silicon material fed from said feeder;

a feed tube for feeding granular silicon material, which is arranged in a lower portion of said first guide tube and movable upward and downward;

a housing incorporating the hopper, the feeder, the guide tube and the feed tube;

a sluice valve for closing an opening of a chamber in the apparatus for manufacturing silicon single crystals; and

a second guide tube which is arranged in the opening of the chamber and which leads granular silicon material to a crucible for melting granular silicon material.

The above objects and other objects and advantages of the present invention will become apparent from the detailed description which follows, taken in conjunction with the appended drawings.

Fig.1 is a vertical sectional view illustrating an apparatus for feeding granular silicon material of the present invention; and

Fig.2 is a schematic illustration showing the state such that a feed tube for feeding granular silicon material is inserted into an opening of a rebound-preventive plate arranged in a portion of an opening of a chamber.

In the present invention, every time the manufacturing of a silicon single crystal is attained, the sluice valve fit for vacuum sealing, which is mounted on at least one position of the housing incorporating the hopper for storing materials, is closed. The pressure inside the housing incorporating the hopper for storing granular silicon material is increased to atmospheric pressure. Subsequently,

granular silicon material is charged into the hopper. When a silicon single crystal is manufactured, the sluice valve is opened, and a feed tube for feeding granular silicon material is lowered. The feed tube for feeding granular silicon material comes to be in the state of passing through the sluice valve. A predetermined amount of silicon material discharged from the hopper is fed by the feeder into a crucible through the feed tube for feeding granular silicon material.

Fig.1 is a vertical sectional view illustrating the apparatus for feeding granular silicon material of the present invention. A housing 11 is arranged on an opening of the chamber 10 of the apparatus for manufacturing silicon single crystals, with the sluice valve 18 positioned between the housing 11 and the opening of the chamber. The inside of the housing 11 communicates with the inside of the chamber 10. The hopper 13 for storing silicon material and the feeder 15 for feeding silicon mateial are arranged inside the housing 11. The hopper 13 is held by a hopper bearer. A first guide tube 16 and a feed tube 19 for feeding granular silicon material are arranged on the upper side of the sluice valve 18. The first guide tube 16 is held by a guide tube bearer 17. A rebound-preventive plate 20 and a second guide tube 21 for leading granular silicon material 22 into the crucible are arranged in the portion of the opening of the chamber 10.

Subsequently, the operation of the apparatus will now be described.

Every time manufacturing of one silicon single crystal is attained, the feed tube 19 for feeding granular silicon material is lifted from the inside of the sluice valve 18 by means of a linkage 23 for lifting and lowering a feed tube. The sluice valve 18 positioned at the lower end of the housing 11 is closed. The pressure inside the housing 11 is elevated to atmospheric pressure, and a cover 12 of the housing 11 which is bolted onto the upper portion of the housing 11 is opened. The granular silicon material 22 as material for manufacturing silicon single crystals is fed into the hopper 13. When particles 22 of silicon attach to the seat of the sluice valve 18 during feeding of the granular silicon material 22, a vacuum-holing ability of the sluice valve 18 becomes insufficient. When the vacuum-holding ability of the sluice valve is insufficient, air is included into the chamber 10 for manufacturing silicon single crystals, which makes the growth of silicon single crystals impossible.

When the next silicon single crystal is manufactured after the granular silicon material 22 has been charged into the hopper 13, the cover 12 of the housing 11 is bolted onto the upper portion of the housing 11. Next, air inside the housing 11 is substituted for inert atmosphere of reduced pressure, and the sluice valve 18 is opened.

After the sluice valve 18 has been opened, the feed tube 19 for feeding granular silicon material is lowered by means of the linkage 23 for lifting and lowring the feed tube and made to pass through the sluice valve 18. The lower end of the feed tube 19 for feeding granular silicon material is inserted into the opening of the rebound-preventive plate 20 arranged in a portion of the opening of the chamber 10. Fig.2 is a schematic illustration showing the state such that the feed tube 19 for feeding granular silicon material is inserted into the opening of the rebound-preventive plate arranged in a portion of the opening of the chamber 10. The linkage for lifting and lowering the feed tube has a predermined stroke. When the sluice valve is closed, the lower end of the feed tube for feeding granular silicon material is located in a position upper than the sluice valve. When the sluice valve is opened, the lower end of the feed tube for feeding granular silicon material is located in a position lower than the sluice valve, passing through the sluice valve.

A silicon single crystal is manufactured by supplying a predetermined amount of the granular silicon material, which corresponds to a pulling amount of the silicon single crystal from the hopper 13 for storing silicon material inside the housing 11, into the crucible by the use of the feeder 15 for feeding silicon material. The predetermined amount of granular silicon material 22 fed by means of the feeder 15 falls from the feeder 15 into the second guide tube 21 through the first guide tube 16 by its weight. When the granular silicon material 22 falls, some of the granular silicon material 22 strikes a cylindrical portion of the second guide tube 21 and rebounds. The rebounded silicon particles can be prevented from attaching to the seat of the sluice valve 18 by causing the feed tube 19 for feeding granular silicon material to pass through the sluice valve 18 as described above. Accordingly, the problem such that the vacuum-holding ability of the sluice valve into between the seat and the disk of the sluice valve can be solved.

Further, inclusion of impurities into the crucible can be prevented by using silica, silicon or teflon for the portion of the first guide tube 16, the second guide tube 21, the feed tube 19 for feeding granular silicon material, the rebound-preventive plate 20 and the like, which contact the silicon particles.

As described above, according to the apparatus for feeding granular silicon material of the present invention, granular silicon material can be recharged into the hopper for storing silicon material without inclusion of air into the chamber, when the manufacturing of each silicon single crystal is attained by means of the apparatus for manufacturing silicon single crystal. Accordingly,

even though the capacity of the hopper corresponds to around one single crystal grown, a continuous operation of the apparatus for a long period of time can be carried out.

Reference signs in the claims are intended for better understanding and shall not limit the scope.

Claims

1. An apparatus for feeding granular silicon material comprising:
a hopper (13) for storing granular silicon material;
a feeder (15) for feeding granular silicon material stored in said hopper; and
a first guide tube (16) for leading granular silicon material fed from said feeder;
characterized by:
a feed tube (19) for feeding granular silicon material, which is arranged in a lower portion of said first guide tube and movable upward and downward;
a housing (11) incorporating the hopper, the feeder, the guide tube and the feed tube;
a sluice valve (18) for closing an opening of a chamber of the apparatus for manufacturing silicon single crystals; and
a second guide tube (21) which is positioned in a portion of the opening of a chamber (10) and which leads granular silicon material to a crucible for melting granular silicon material.

2. The apparatus of claim 1, characterized by further comprising a linkage (23) for lifting and lowering the feed tube for feeding granular silicon material.

3. The apparatus of claim 1, characterized by further comprising a rebound-preventive plate (20), which prevents scattering of the granular silicon material rebounded from the second guide tube.

FIG. 1

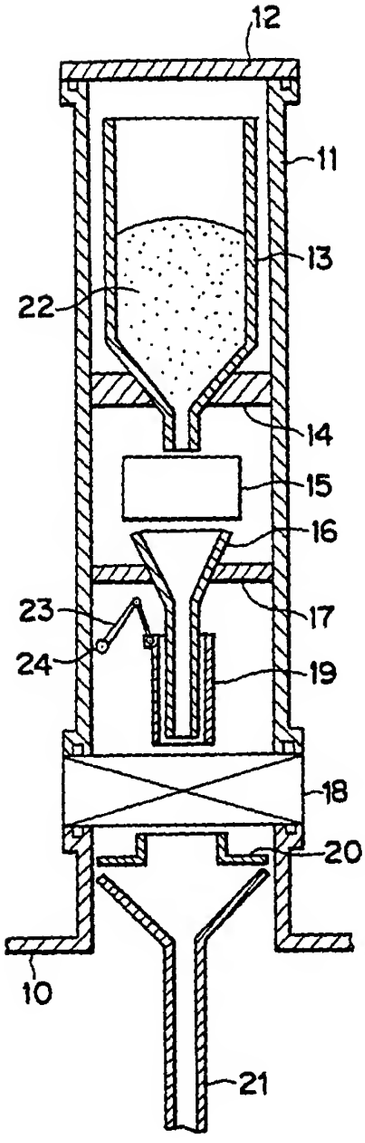
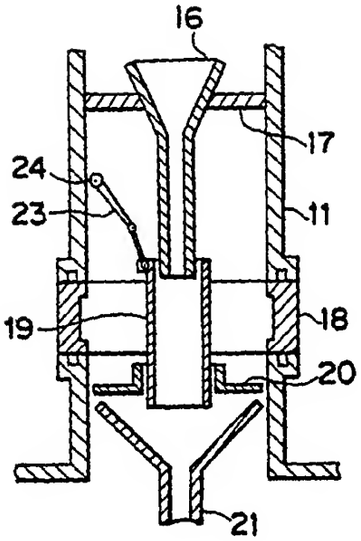


FIG. 2



European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 11 2760

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	EP-A-0 314 858 (LEYBOLD AG) * Column 4, lines 1-47; column 5, lines 8-15; figure 1 *	1,2	C 30 B 15/02
A	US-A-3 998 686 (MEILING et al.)		
A	US-A-4 002 274 (RICE)		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

C 25 C
C 30 B
B 65 G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18-10-1990	COOK S.D.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P0401)